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TESTS OF REPELLENTS AGAINST TABANIDS 1/

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Horse flies and deer flies (Tabanidae) are difficult to control either as larvae or as adults. Therefore, consideration has been given to the use of repellent sprays for the protection of livestock from attack by these pests. A large number of synthetic organic compounds, some of which were effective mosquito repellents, were obtained from the Orlando, Fla., laboratory for testing at Corvallis, Oreg. Since only small quantities (1 to 5 grams) of the materials were available, it was necessary to make most of the tests on small animals in the laboratory. This paper reports the results of laboratory tests on the deer fly (Chrysops discalis Will.) and limited field tests on cattle of a few materials against mixed populations of tabanids at Summer Lake, Oreg., during the summers of 1949 and 1950.

Laboratory Tests

White mice were used as the host animals in a technique similar to that employed by Eddy and McGregor (1949) in conducting tests against Stomoxys calcitrans. Each mouse weighed approximately 25 grams and was sprayed with 2.5 ml. of a 0.25-percent acetone solution of the chemical. Application was made with a bulb-type hand atomizer that delivered coarse droplets, so that the loss of chemical due to misting was minimized. Each mouse was confined in a 4-mesh hardware-cloth cage, approximately 1 inch in diameter and 4 inches long, which was rotated by hand during the spraying. After the spraying the mouse was placed in a small screen cage for about an hour to permit the acetone to evaporate, and then in a clean hardware-cloth cage for testing. The cage containing the mouse was placed in a widemouthed quart fruit jar. About 30 to 40 female deer flies that had been collected with an insect net near the alkali flats of Summer Lake were introduced into each jar.

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Usually 10 chemicals were tested at a time. A mosquito repellent containing 60 percent of dimethyl phthalate, 20 percent of Indalone, and 20 percent of 2-ethyl-1,3-hexanediol was included in each series of tests for comparison. This mixture, known as M-250, was developed by the Bureau of Entomology and Plant Quarantine and was used by the Armed Forces during World War II. An acetone-sprayed mouse was used as a check with each series. It was found that the flies would usually bite check mice within 10 minutes.

During exposure of the mice to the flies, constant observations were made for landing and biting. As soon as a definite bite was observed, the test was terminated. If a bite was not obtained in 45 to 60 minutes, the test was stopped for 1 hour or longer, and then the mouse was exposed to other flies. This procedure was continued until a bite was obtained or the test was terminated owing to the lateness of the hour. For this reason the repellent times are not always precise. Some chemicals caused a rapid retreat of the fly when it touched the treated mouse; others had little effect. Fumigation may have been a factor with some of the chemicals that gave long protection times. The best compounds from several series were usually retested.

This method of testing eliminated many materials on the basis of one test. Promising compounds were subjected to further tests. Some of the materials that repelled flies for 200 minutes or more in the first test failed to protect for a similar period when retested.

In the accompanying lists are included 153 chemicals that repelled deer flies for less than 125 minutes; 80 chemicals that gave repellent times of 125 to 225 minutes, several of which were tested twice; and 24 materials that repelled for more than 225 minutes. The standard repellent M-250 gave average protection times of 138 and 114 minutes in tests conducted in 1949 and 1950, respectively. 2-Amino-3-isobornyloxy-2-methyl-1-propanol (O-4265) and Santomerse DT (O-16434) were consistently more effective than the other materials, the average protection times being 788 and 1,926, respectively.

Field Tests

Five of the materials that showed promise in the laboratory were tested on calves. Various pyrethrum and allethrin sprays were also tested. The materials were applied undiluted with a small hand sprayer at the rate of 10 ml. per calf. Effectiveness was determined by counting the tabanids on treated and untreated animals from 2 to 5 times per day. Unless otherwise stated, all observations refer to discalis.

2-Amino-3-isobornyloxy-2-methyl-1-propanol prevented biting for 1 to 3-1/2 days, and Santomerse DT for 1-1/2 to 2-1/2 days. They were the best materials tested. Santomerse DT remained in the hair for several days, as evidenced by the lather caused when a few drops of water were rubbed on the animal. However, it was the most injurious material tested, causing the hair to come out.

5-Methyl-5-nitro-2-propyl-m-dioxane (0-7102) was more effective than 1,1'-oxybis/3-hexyloxy/-2-propanol (0-4200), but the latter compound appeared to be more effective against Tabanus sonomensis O. S. and productus Hine, giving fairly consistent protection for 1 or 2 days. M-250 was the least effective material tested in the field, giving protection for 2 to 5 hours.

The pyrethrum sprays gave poor protection unless used at very high concentrations. The pyrethrins at 0.1 to 0.3 percent concentration plus p-aminophenol or triple-distilled tall oil applied at the rate of 1 quart per animal gave 1/2 to 2-1/2 days' protection as emulsion sprays. Piperonyl butoxide in combination with the pyrethrins was somewhat more effective.

In general, the repellency of the various materials was similar to that in the laboratory tests. However, all except the pyrethrins had some deleterious effect on the skin and hair of the animal.

Summary

A total of 258 synthetic organic compounds were tested in the laboratory as repellents of the deer fly (Chrysops discalis Will.) with white mice as the host animals. Only a few of the compounds showed any promise as long-lasting repellents, 2-amino-3-isobornyloxy-2-methyl-1-propanol (0-4265) and Santomerse DT (0-16484) being the most effective.

Five of the best materials were tested on calves in the field against mixed populations of tabanids. The most effective were 2-amino-3-isobornyloxy-2-methyl-1-propanol and Santomerse DT. All the materials tested except the pyrethrins were slightly deleterious to the hair and skin of the animals. The protection obtained ranged from about 2 hours to 3-1/2 days. Pyrethrum sprays were not very effective unless used at very high concentrations.

Literature Cited

Eddy, Gaines W., and W. S. McGregor. 1949. Use of white mice for testing materials used as repellents and toxicants for stable flies. Jour. Econ. Ent. 42(3): 461-463.

Orlando No. (O-)	Chemicals repelling for less than 125 minutes
62	Phenol, o-phenyl-
126	Phenol, p-tert-butyl-
164	Ethanol, 2-(alpha-methylbenzyloxy)-
242	Ethanol, 2-(2-butoxyethoxy)-, acetate
374	2-Propanol, 3-(2-cyclohexyloxy-1-methylethoxy)-
416	Ethanol, 2-(2-cyclohexyloxyethoxy)-
667	Cinnamic acid, ethyl ester
751	Hendecanoic acid, hydroxy-, lactone
910	2H-Pyran-6-carboxylic acid, 3,4-dihydro-2,2-dimethyl-4-oxo-,ethyl ester
918	Ethanol, 2-phenoxy-
920	2-Butanol, 3-butoxy-
1022	Anthranilic acid, methyl ester
1029	Acetophenone, p-ethoxy-
1040	Ethanol, 2-(benzyloxy)-
1371	Caproic acid, alpha-ethyl-
1463	Ethanol, 2-(N-ethylanilino)-
1650	Isobutyric acid, alpha-hydroxy-, phenethyl ester
1656	Ethane, 1,2-dichloro-
1774	Phenethyl alcohol, p-isopropyl-
1788	Mandelic acid, isopropyl ester
1789	Mandelic acid, butyl ester
2026	Cinnamic acid, isopropyl ester
2065	Hendecenoic acid
2220	Ethanol, 2-(diethylphenoxy)-
2313	Cinnamic acid, allyl ester
2320	Levulinic acid, benzyl ester
2375	s-Trioxane, 2,4-bis(trichloromethyl)-
2419	Phthalimide, N-sec-butyl-
2518	Phenethyl alcohol, p-bromo-
2540	Acetoacetic acid, 2-(2-butoxyethoxy)ethyl ester
2701	Ether, piperonyl propyl
2719	Phenethyl alcohol, p-chloro-
3166	Lactic acid, 2-(2-butoxyethoxy)ethyl ester
3387	Butyl sulfone
3435	Safrole, dihydro-
3451	Phenol, phenethyl-
3559	1,3-Dioxolane-4-methanol, 2-furyl-
3572	Tartaric acid, idisopropyl ester
3880	Phenethyl alcohol, dichloro-
3916	Bicyclo/2.2.1/-5-heptene-2,3-dicarboxylic acid, cis-, dimethyl ester
3957	Cyclohexanecarbonitrile, 1-hydroxy-x-methyl-
3960	Hendecanal, 2-methyl-
4132	Bicyclo/2.2.1/-5-heptene-2,3-dicarboxylic acid, diethyl ester
4202	Mandelic acid, hexyl ester
4203	Mandelic acid, isobutyl ester
4298	Isobutyric acid, alpha-hydroxy-, phenylpropyl ester
4343	Acetic acid, chloro, 2-nitroisobutyl ester
4562	1,2-Propanediol, 3-(1,3-dimethylbutoxy)-
4841	Acetamide, alpha-(2-butoxyethoxy)-N-cyclohexyl-

Orlando No. (O-)	Chemicals repelling for less than 125 minutes - continued
4999	Cyclohexaneacetic acid, alpha-cyano-, ethyl ester
5023	2-Cyclohexene-delta-1,alpha-acetic acid,alpha,3,5,5-tetramethyl-, methyl ester
5027	1,3-Dioxolane,2-hexyl-4-(methoxymethyl)-
5032	1,4-Dioxaspiro/5.5/hendecan-3-ol, 7-methyl-
5079	5-m-Dioxanol, 2-(1-ethylamyl)-
5103	5-m-Dioxanol, 2-(1-ethylpropyl)- and 1,3-Dioxolane-4-methanol, 2-(1-ethylpropyl)-
5508	Acetamide, N,N-diisoamyl-
5511	Cyclohexanol, 2-(2,5-xylyl)-, trans
5518	Benzaldehyde, p-propoxy-
5519	Benzyl alcohol, p-propoxy-
5521	Benzyl alcohol, o-methoxy-
5522	Phenethyl alcohol, p-methoxy-
5524	Acetanilide, N-propyl-
5533	m-Dioxane, 4-(p-methoxyphenyl)-5-methyl-
5542	Ethanol, 2,2'-thiodi-, diacetate
5712	Benzaldehyde, p-butoxy-
5714	Benzaldehyde, p-isopropoxy-
5844	Benzyl alcohol, p-isoamoxy-
5863	2-Furanacrylic acid, 2-ethoxyethyl ester
5868	Benzaldehyde, o-hexyloxy-
5926	Butyraldehyde, alpha-(2-cyanoethyl)-alpha-ethyl-
5946	2,4-Octanediol
5947	3,5-Nonanediol, 4-methyl-
5960	2-Indanol, 1-methoxy-
5963	2,4-Heptanediol, 6-methyl-
6094	Caproic acid, 3-hydroxypropyl ester
6124	Butyric acid, amyl ester
6136	Cyclohexanecarboxylic acid, 1-hydroxy-, isoamyl ester
6145	Caprylic acid, alpha-hydroxy-, butyl ester
6207	Nitrilotricarboxylic acid, triethyl ester
6210	Caproin
6217	Hydracrylic acid, beta-phenyl-, isopropyl ester
6218	Hydracrylic acid, beta-phenyl-, propyl ester
6220	Hydracrylic acid, beta-phenyl-, methyl ester
6225	Cyclohexaneacetic acid, 1-hydroxy-, propyl ester
6226	Cyclohexaneacetic acid, 1-hydroxy-, butyl ester
6238	1,3-Dioxolan-4-one, 2,2-dimethyl-5-phenyl-
6245	Succinamic acid, N,N-dibutyl-, propyl ester
6251	Succinamic acid, N,N-dipropyl-, propyl ester
6254	Propionic acid, 3-hydroxycyclohexyl ester
6275	Succinamic acid, N,N-diethyl-, isobutyl ester
6319	Propionic acid, 1,6-hexanediol diester
6381	1,3-Dioxolane-2-propionic acid, 2-methyl-, cyclohexyl ester
6383	Pivalic acid, diester with 1,5-pentanediol
6387	Enanthic acid, 5-hydroxyamyl ester
6397	Glutaramic acid, N,N-diisopropyl-, propyl ester
6398	Succinamic acid, N,N-diethyl-, 2-methoxyethyl ester
6484	Adipamic acid, N,N-diisopropyl-, methyl ester
6494	Cyclohexanecarboxylic acid, 1-hydroxy-, 2-ethoxyethyl ester

Orlando No. (O-)	Chemicals repelling for less than 125 minutes - continued
6498	Cyclohexanecarboxylic acid, 1-hydroxy-, 2-butoxyethyl ester
6500	Cyclopentanecarboxylic acid, 1-hydroxy-, 2-butoxyethyl ester
6502	1,3-Dioxolane-2-propionic acid, 4-methoxymethyl-2-methyl-, ethyl ester
6503	Benzyl alcohol, alpha-propoxymethyl-
7014	Phenethyl alcohol, o-methyl-
7081	m-Dioxane, 5-methyl-5-nitro-2-(1-propenyl)-
7102	m-Dioxane, 5-methyl-5-nitro-2-propyl-
7146	10-Hendecenamide, N,N-diethyl-
7178	Acetic acid, chloro-, tetrahydrofurfuryl ester
7179	1-Oxaspiro[2.5]octane-2-carboxylic acid, 2-methyl-, allyl ester
7187	Acetic acid, cyano-, cyclohexyl ester
7227	Hydrocinnamic acid, alpha, beta-epoxy-alpha,beta-dimethyl, propyl ester
7228	m-Dioxane, 2-isopropyl-5-methyl-5-nitro-
7343	Ether, benzyl 2-methylallyl
7353	Ethane, 1-benzyloxy-2-(2-methylallyloxy)-
7371	Acetic acid, cyano-, 4-methylcyclohexyl ester
7430	1,3-Dioxolane-4-methanol, 2-methyl-2-phenyl-
7434	Propionic acid, beta-chloro-, tetrahydrofurfuryl ester
7555	2,4-Hexanediol, 3,4-dimethyl-
7692	1,4-Dioxaspiro[4.5]decane-2-methanol, trimethyl-
7695	Piperidine, 1-(diethylsulfamyl)-
7838	2-Cyclohexene-1-carboxylic acid, 2,6-dimethyl-4-
7943	Butyric acid, 2-oxocyclohexyl ester
7986	Diglycolic acid, dibutyl ester
8137	2-Propanol, 1-[2-(3,3,5-trimethylcyclohexyloxy)-propoxy]-
8281	Ethanol, 2-(2-ethylhexyloxy)-
8283	2-Propanol, 1-(2-ethylhexyloxy)-
8606	Acetamide, alpha, alpha, alpha-trichloro-N-(2-chloroethyl)-
8632	3,5-Xylenol, 4-chloro-
8906	Benzaldehyde, m-nitro-
9006	1,5-Dioxaspiro[5.5]hendecane-3-ol, 8-methyl-
9221	Cyclopentenol, cyclopentenyl
10017	Benzyl alcohol, alpha-propenyl-
10037	3-Buten-2-ol, 4-phenyl-
10516	Acetophenone, 4-methoxy-3-methyl-
10539	5-Nonanone, oxime
11189	Phenol, 2,3-dimethoxy-
11190	Hydrocinnamic acid, beta-hydroxy-alpha-methyl-, ethyl ester
11231	1-Pentanol, 5-phenyl-
11294	Cyclohexanecarboxylic acid, 2-oxo-1-propyl-, ethyl ester
11319	1-Propanol, 3-benzyloxy-
11588	2-Pentenoic acid, 4-methyl-, ethyl ester
12000	1,2-Cyclohexanedicarboxylic acid, cis-, diethyl ester
12089	Quinaldine, 1,2,3,4-tetrahydro-1-propionyl-
12130	Crotonanilide, N-methyl-
13039	2,3-Octanediol
13058	1,2-Octanediol
13105	1,2-Cyclohexanedicarboximide, N-sec-butyl-
13179	4-Heptyne-3,6-diol, 3-isopropyl-2,6-dimethyl-

Orlando No. (O-)	Chemicals repelling for less than 125 minutes - continued
13204	Caproic acid, 2-(2-hydroxyethoxy)ethyl ester
13208	2,3-Pinanediol
14253	Acetamide, N-allyl-alpha-butoxy-
14254	Glycolamide, N-amyl-, benzoate
14454	Isobutyric acid, alpha-hydroxy-, phenyl ester, acetate
14484	Lactic acid, butoxyethoxyethyl ester

Orlando No. (O-)	Chemicals repelling for 125 to 225 minutes
6	Thiocyanic acid, 2-(2-butoxyethoxy)ethyl ester (Lethane 384)
300	Ethanol, 2-[2-(2-ethylhexyloxy)ethoxy]-
399	Phosphoric acid, tributyl ester
558	Pinene, ether with ethylene glycol
753	Coumarin
925	Acetamide, N-amyl-alpha-butoxy-
1023	Cyclohexanol, 2-cyclohexyl-
1170	Anisyl alcohol
1208	Acetamide, N,N-diamyl-
1643	Mandelic acid, ethyl ester
1881	Acetamide, N-cyclohexyl-alpha-(2-methylallyloxy)-
2103	Ethanol, 2-(x-chloro-y-ethylphenyl)-
2133	Cyclohexanol, 2-phenyl-
2225	Ethanol, 2-(p-chlorophenoxy)-
2269	Benzyl ether
2484	Acetanilide, N-butyl-
2495	Ethanol, 2-(p-ethylphenoxy)-
2638	Isobutyranilide, N-ethyl-
2718	Phenethyl alcohol, ar-ethyl-
2812	Ethanol, 2-(p-sec-butylphenoxy)-
2971	Succinimide, N-amyl-
3056	1-Hexen-3-one, 1-furyl-5-methyl-
3130	Lactic acid
3346	Phenol, 2,4,6-tris(dimethylaminomethyl)-
3358	1,3-Propanediol, 2-amino-2-ethyl-
3815	Piperonylic acid, ethyl ester
3882	Ethanol, 2-(diethylphenyl)-
4145	4-Cyclohexene-1,2-dicarboximide, N-butyl-
4337	Ether, terpinyl triethylene glycol
4339	Glycine, N-butyl-, isobornyl ester
5024	5-m-Dioxanol, 2-hexyl-
5507	Cyclohexanol, 2-m-tolyl-, trans-
5540	2-Furanacrylic acid, 2-methoxyethyl ester
5562	1-Propanol, 3-(p-methoxyphenyl)-
5611	Succinic acid, alpha-cyano-beta-methyl-, diethyl ester
5824	Citronellal, 7-hydroxy-, dimethyl acetal
5835	2,4,8,10-Tetroxaspiro[5,5]hendecane, 3,9-diethyl-
5854	Butyric acid, 1,2,3,4-tetrahydro-2-naphthyl ester
5883	Benzyl alcohol, p-sec-butoxy-
5911	2,4-Hexanediol, 3-ethyl-
5949	2,4-Nonanediol
5955	2,4-Octanediol, 7-methyl-
6133	Cyclohexanecarboxylic acid, 1-hydroxy-, cyclopentyl ester
6135	Caprylic anhydride
6138	Cyclopentanecarboxylic acid, 1-hydroxy-, cyclohexyl ester
6152	Butyric acid, 3-phenylpropyl ester
6166	Succinamic acid, N,N-diethyl-, ethyl ester
6168	Succinamic acid, N,N-diethyl-, propyl ester
6216	Hydracrylic acid, beta-phenyl-, ethyl ester

Orlando No. (O-)	Chemicals repelling for 125 to 225 minutes (continued)
6221	Butyric acid, beta-hydroxy-beta-phenyl-, ethyl ester
6248	Succinamic acid, N,N-diamyl-, propyl ester
6249	Succinamic acid, N,N-diamyl-, ethyl ester
6252	Succinamic acid, N,N-dipropyl-, ethyl ester
6361	Glutaramic acid, N,N-diethyl-, ethyl ester
6388	Succinamic acid, N,N-diethyl-, sec-butyl ester
6400	Succinamic acid, N,N-dipropyl-, methyl ester
6485	Adipamic acid, N,N-dipropyl-, methyl ester
6515	2-Cyclohexene-1-carboxylic acid, 2-methyl-4-oxo-6-propyl-, ethyl ester
6617	Succinamic acid, N,N-diethyl-, allyl ester
7121	Hydrocinnamic acid, alpha, beta-epoxy-beta-methyl-, allyl ester
7126	Hendecenoic acid
7209	4-Cyclohexene-1,2-dicarboximide, N-allyl-
7409	1,2-Cyclohexanedicarboximide, N-butyl-
8295	Ethanol, 2-(2,5-xylyloxy)-
8439	Bicyclo[2.2.1]-5-heptene-2,3-dicarboxylic acid, methyl propyl ester
10511	Propiophenone, oxime
10517	Valerophenone, p-methoxy-
10531	Cyclohexaneglyoxylic acid, 2-oxo, ethyl ester
11089	Acetoacetic acid, ethyl ester, oxime acetate
11159	Isocaproic acid, alpha-oxo-, ethyl ester, oxime
11314	beta-Nicotyrine
11599	Benzoic acid, 2,2-dimethylpropyl ester
12142	2,4-Heptanediol, 5-ethyl-
12144	2,4-Decanediol
12181	4,6-Octanediol, 2-methyl-
13108	1,2-Cyclohexanedicarboximide, N-isobutyl-
13138	4-Nonyne-3,6-diol, 3,6,8-trimethyl-
13204	Caproic acid, 2-(2-hydroxyethoxy)ethyl ester
13205	Cyclohexanol, 1-phenyl-
14249	Fencholic acid

Orlando No. (O-)	Chemicals repelling for more than 225 minutes
92	Thanite (mixture of fenchyl and isobornyl thiocyanoacetates)
774	Ethanol, 2-[2-(3-methyl-2-norcamphanylmethoxy)ethoxy]-
1000	Bicyclo[2.2.1]-5-heptene-2,3-dicarboximide, N-amyl-
1442	Propanediol, x-(2-ethylbutoxy)-
1492	Bicyclo[2.2.1]-5-heptene-2,3-dicarboximide, N-(mixed)amyl-
4200	2-Propanol, 1,1'-oxybis[3-hexyloxy]-
4262	4-Morpholineacetic acid, isobornyl ester
4265	1-Propanol, 2-amino-3-isobornyloxy-2-methyl-
4561	1,2-Propanediol, 3-(2-ethylhexyloxy)-
4641	Acetic acid, thiocyano-, chloroisobornyl ester
5918	2-Naphthol, decahydro-
6269	Succinamic acid, N,N-dipropyl-, isopropyl ester
6348	Succinamic acid, N,N-diisopropyl-, propyl ester
6358	Glutaramic acid, N,N-diisopropyl-, ethyl ester
6373	Glutaramic acid, N,N-dipropyl-, methyl ester
6375	Glutaramic acid, N,N-diisopropyl-, methyl ester
6393	Succinamic acid, N,N-dipropyl-, sec-butyl ester
6408	Succinamic acid, N,N-diisobutyl-, ethyl ester
6486	Adipamic acid, N,N-diisopropyl-, ethyl ester
6534	2-Cyclohexene-1-carboxylic acid, 6-ethyl-2-methyl-4-oxo, ethyl ester
7082	m-Dioxane, 5-ethyl-5-nitro-2-(1-propenyl)-
7090	m-Dioxane, 5-ethyl-5-nitro-2-propyl-
7392	4-Cyclohexene-1,2-dicarboximide, N-propyl-
16484	Santomerse DT (a salt of an alkyl-substituted aromatic sulfonic acid)